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Modeling the green supply chain in the context of sustainable development

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Abstract

Sustainable development (SD) requires companies to take into account both the social and environmental consequences within their activities. This paper presents research about green supply chain management and highlight the differences between green supply chain and traditional supply chain management. Then, the paper analyses the sources of the risk in green supply chain according to the SD. Sustainable development has gained much attention in recent years as a "challenge" for all businesses. Finally, paper makes a modeling of the green supply chain in the context of SD and presents an interface tool for risk assessment in the green supply chain.

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Keywords: Green supply chain,traditional supply chain, sustainable development, risk management, modeling, risk.

1. Introduction

Sustainable development requires companies to take into account both the social and environmental consequences within their operations and their daily activities. Sustainability is currently a common preoccupation on both national and international level. The deciding issue of sustainability is the opposition between the population's need to grow on one side and the planet's resources and the continuous degradation of the environment on the other side. Sustainable development requires companies to take into account both the social and environmental consequences within their operations and their daily activities. This implies, first of all, reducing the pollution of the environment,

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whilst in downstream this is also found within society welfare, and thus in social conditions. There are a series of rules and procedures imposed by the European Union, and every member state must consider the promulgated imperatives and considerations.

The paper emphasizes the implications of sustainable development, climate changes as well as the implications of the traditional supply chain and the green supply chain. Next a series of risk factors are presented, of which the greenhouse gases are a matter of importance as an analysis on European Union level and within Romania is presented. By taking the imbalances into account, the main risk is carbon dioxide (greenhouse gases) and in this matter the optimisation of the supply process is presented by considering the imperatives of sustainable development and the associated risks. Finally the architecture and modelling of the green supply chain within this context is presented and discussed. The paper ends with conclusions and further possible research extensions.

2. Sustainable development and climate change

The foundation of the requirements for sustainable development was set in 2000 by the European Commission. This Commission launched in April 2000 the tool of "triple basis line" on the request of measuring their value, having as subordinated issues:

- environment: the impact of the campaign activities on the environment broadly – natural resources usage, rejecting the entire nature, territory occupation;
- economic: collecting financial performances, their impact on the economic growth in their field of activity and obeying the ethical principles in business;
- social: the social consequences of the company as a whole and its representatives: employees, solicitors, clients, local community (European Commission, 2013).

Sustainability refers to the ability of being durable that persists with time. So, in (Shuo, Wei, 2013) "…The essence of sustainable development is creating environmental and social conditions for earth enduring system, so that can benefits mankind. It clearly indicates the absolute dependence of human on earth enduring system". The sustainability development can be seen as an additional requirement in the development of organization processes and achieving the objectives of the enterprise (Ivascu et al., 2014; Moraru et al., 2010).

The concept of sustainable development leads to the analysis of the factors which contributed to the changes in the environment and in the health of the population due to polluting of the water, air, ground and others. These decisive factors are especially the greenhouse gases which release carbon dioxide and methane into the atmosphere. Greenhouse gases (GHG) are developed in the environment following natural processes and human activities. Water steam is the most frequent in the atmosphere. Due to human activities considerable other quantities of other GHG are released into the atmosphere, thereby increasing their atmospheric concentration – and thus intensifying the greenhouse gases and warming up the climate.

These greenhouse gases are released especially by:

- burning of fossil fuels (coal, rock oil, natural gases) to produce energy for transportation, industry and households (CO_2);
- agriculture and deforestation;
- storage of household waste and the lack of local and national waste management;
- the use of fluorinated industrial gases.

The main sources of carbon dioxide emissions are the combustion of the energetic sector, the emissions from road transport, non-industrial combustion plants and combustion in the manufacturing industry. Within literature studies (Srivastava, 2007; Bajdore et al., 2011; Hugos, 2011; Sarkis, 2011) one can observe that transportation is a polluting element for which actions to reduce the impact on the atmosphere have to be imposed. By analyzing the implications of sustainability one can observe that the development possibility on the sustainability axis does not exist without the actual support of technology. Technology is present in every activity, being an element which sustains and contributes to the optimum development of a company's processes. This tool can be used to optimize

the activities and also for the supply chain. The recent technological advancement allows a series of actions to optimize transportation and to develop an optimal architecture. The sustainable balance of the system is heavily influenced by risk appearance. Evaluating risk in the context of sustainable development leads to an optimal handling of these risks, to the stability of the system, without compromising the needs of future generations. Developing the balance at company level implies evaluating associated risks and hazards so that the company contributes to the welfare of the society and the planet.

3. Green supply chain and traditional supply chain

Supply chain is defined and interpreted within the literature by several authors. Ganesh and Harrison (1995), define the supply chain as"a Network of facilities and distribution options that performs the functions of procurement of materials, transformation of these materials into intermediate and finished products, and the distribution of these finished products to customers". Chopra and Meindl (2003) highlight that"a supply chain consists of all stages involved, directly or indirectly, in fulfilling a customer request. The supply chain not only includes the manufacturer and suppliers, but also transporters, warehouses, retailers, and customer themselves".

In 2011, based on Hugos, five major factors within the supply chain which interact amongst them are presented (Figure 1).

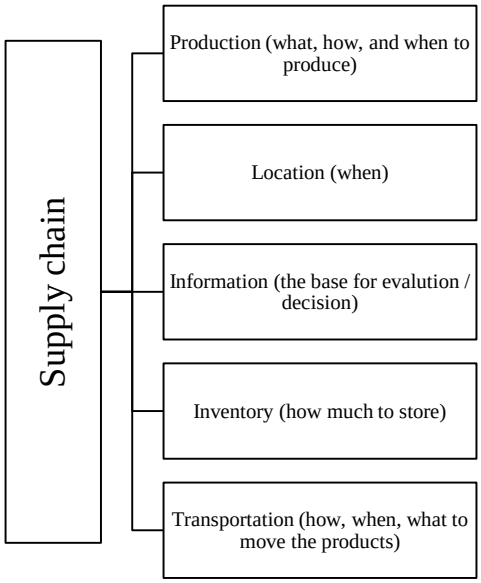

Fig.1. Five major factors in the supply chain (after Hugos, 2011)

Compared to the supply chain, the green supply chain (GSC) implies approaching factors according to the imperatives of the environment and adopting strategies in the sense of sustainable development. Hence, Bajdor and Grabara (2011) systematize the concept in the following manner (Figure 2)

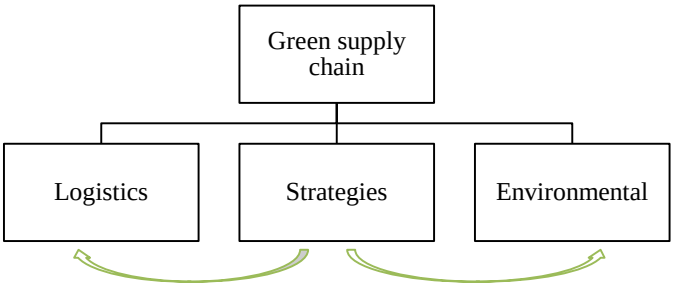

Fig. 2. Green supply chain (after Bajdor and Grabara, 2011)

Green supply chain management (GSCM) has already won an increased interest within researchers and companies (Ojo, 2013; Darnall, 2008; Sheu, 2005). The growing importance of this concept is due primarily to the deterioration of the environment, inefficient waste management and diminishing raw material resources. Adding the term "green" to supply chain implies approaching the supply chain from the traditional perspective by corroboration/combination with the natural environment. Zhu et al. claims that GSCM can be considered as an environment innovation. Zhu and Sarkis highlight that GSCM has ranged from green purchasing to integrated supply chains starting from supplier, to manufacturer, to customer and reverse logistics, which is "closing the loop". Srivastava (2007) said that GSCM can be defined as "integrating environmental thinking into supply chain management, including product design, material sourcing and selection, manufacturing process, delivery of the final product to the consumers as well as end-of-life management of the product after its useful life".

4. Transportation's role in reducing greenhouse gas emissions

4.1. Greenhouse Gas Emissions and Global Climate Change

Transportation, as a component of supply chain has a significant impact on the environment (Coyle et. al., 2010; Cioca et al., 2015). Transportation is a complex contributor to national greenhouse gas emissions, and can be part of the Nation's solution to the climate change challenge.

The Intergovernmental Panel and Climate Change (IPCC) estimates that in the absence of adopting some policies and solutions to reduce GHG, emissions will increase to 110% between the years 2000 and 2030. The IPCC projects that global temperatures will rise between 2°F to 11.5°F by 2100, and global sea level will rise between 7 to 23 inches. More recent estimates that include the effects of polar ice sheet melting suggest a possible 3 to 4 foot sea level rise. IPCC said that, global GHG emissions must be reduced to 50 to 85 percent below year 2000 levels by 2050 to limit warming to 2.0°C to 2.4°C (3.6°F to 4.3°F). To reach this target, GHG emissions from all sectors must be reduced through a multi-generational effort (Report US, 2010). By analysing the quantity of carbon dioxide emissions at European Union level, it was found that the largest quantity has resulted from producing electric and thermic energy within each individual country. For example, producing energy based on coal within EU states has generated around 950 million tonnes of CO2 emissions in the year 2005, which represents 24% of the total CO2 emissions in the EU.

Table 1. Share of CO2 emission by activity sectors in the UE states (data source: International Energy Agency – IEA), and Share of CO2 emission by activity sectors in Romania (data source: International Energy Agency – IEA)

Domain	Share of CO2 emission by activity sectors in the UE states	Share of CO2 emission by activity sectors in Romania
Electricity and heat production	40.2 %	48 %
Other industries	4.2 %	8.1 %
Construction and manufacturing Industry	16.9 %	16.7 %
Transport	19.2 %	18.2 %
Rezidential sector	12.1 %	6 %
Other commercial sectors, public and agriculture	6.1 %	3 %

After the electric and thermal energy sector, the transportation sector is the next big polluting element given all companies divided based on activity sectors. Graphic representation is presented in Table 1 for the situation of the European Union and in Table 1 for Romania. One can observe that in Romania the situation is improved by 1.2% due to the fact that progress has been made to reduce emissions from the transportation sector.

The transport system is the most important economic activity among the components of business logistics systems. It is fast becoming a complex factor in determining the difference between profit and loss. This concept is the essential link between the extraction of natural resources; the fabrication of industrial, commercial, and consumer products; and the final distribution of goods to wholesalers, retailers, and end users.

Bringing the GSC concept into discussion, transportation needs to be adopted according to the environment and by implementing strategies in this sense. Speaking about GSC, certainly all key factors must be re-evaluated so that the impact of GSC on society and environment is minimised. According to location, the type of transportation can be different, whilst the impact on the environment is also different. Within the supply chain transportation is used in the following situations (Figure 3).

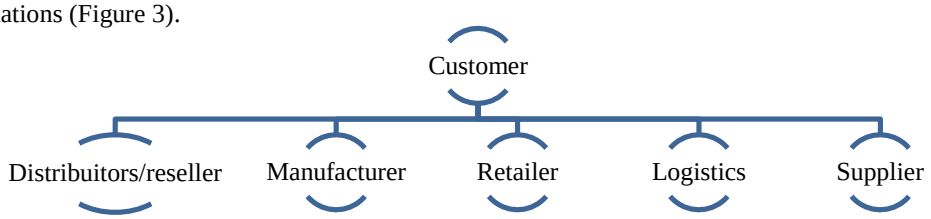

Fig. 3. Typologies of transportation

As for transport, the fast emissions growth was driven by emissions from the road sector, which increased by 52% since 1990 and accounted for about three quarters of transport emissions in 2011 (IEA, 2013).

4.2. Developing a low-carbon supply chain

Using bio or electric electric fules is outlined. Moreover reusing is emphasized, being a condition for sustanable development. In order to reduce the air pollution several strategies can be adopted: introduce low-carbon fuels, introduce electrical transport, increase vehicle fuel economy, improve transportation system efficiency, reduce carbon-intensive travel activity, and price carbon.

4.3. Proposed Green Supply Chain Architecture

Based on the implications of sustainability and the traditional supply chain, the GSC architecture in presented in the following figure (Figure 4). The fact that at the base of adopting this new concept the dimensions of

sustainability have to be adopted is highlighted, while transportation emissions must be reduced by rendering them more efficient.

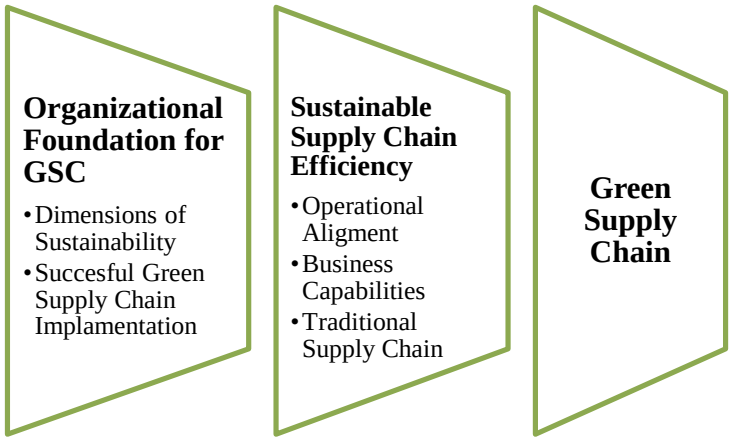

Fig. 4. Deployment Diagram for GSC

5. Conclusions

The GSC concept imposes companies to adapt to present requirements of the economy, being a step in their development. Approaching the supply chain by a green perspective first of all implies an increased attention given towards society and the environment. Thinking green, probably, has become a normal activity because all the activities are headed towards sustainability and hence towards the environment and society. The transportation activity represents a pillar of support in the economic environment, but it contributes to polluting the environment in the same time. In spite of the reduction of emissions within the last decades, traditional supply chain still remains a major source of pollution.

In order to reduce and control CO2 emissions resulted from transportation activities there is a proposition for a directive of the European Parliament and the Council (the prevention and the integrated control of pollution). In order to prevent, reduce and control CO2 emissions resulted from transportation, a series of measures and actions are necessary, as are the following:

- the increased use of new technologies,
- introducing dispositions regarding inspections and improving environment protection,
- stimulating innovation and the development and use of new techniques.

This paper systematizes data relating to supply chain in Romania and the EU. By modeling the supply chain process is presented its architecture. The GSC concept imposes companies to adapt to present requirements of the economy, being a step in their development. Approaching the supply chain by a green perspective first of all implies an increased attention given towards society and the environment. Thinking green, probably, has become a normal activity because all the activities are headed towards sustainability and hence towards the environment and society.

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